International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Review Article

RADIAL HEAD REPLACEMENT VERSUS OPEN REDUCTION AND INTERNAL FIXATION IN MANAGEMENT OF UNSTABLE, MULTI-FRAGMENTED RADIAL HEAD FRACTURES- REVIEW

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ABSTRACT

The radius or radial bone is one of the two bones of the forearm, the other being the ulna. At the elbow, it joins with the capitulum of the humerus and in a separate region with the ulna at the radial notch. The radial part that articulates with the capitulum of the humerus is called radial head. Radial head fractures are the most common fractures occurring around the elbow. Radial head fractures can occur in isolated, associated fractures, dislocations and ligament injuries. In general the treatment of the radial head fractures is based on the fracture type and the presence of any associated injury. The treatment of choice for the radial head fractures is controversial. The goal of treatment is complete restoration of the joint and its function. According to developing techniques, instrumentation and implants, open reduction and internal fixation or radial head replacement for unstable, multi-fragmented radial head fracture results in better outcome.

Keywords: Radial head fracture, Unstable, Multi-fragmented, Open reduction and internal fixation (ORIF), Radial head replacement

INTRODUCTION

The radial head (at the top of radius bone and just below elbow)is very important for elbow kinematics. Radial head fracture is the most common fracture occurring around the elbow and its effective treatment plan is challenging and the outcome depends on the type of fracture and the technique used. The treatment options, early motion, fragment excision, radial head excision, repair or replacement are influenced by fracture fragment number, displacement, impaction, associated injuries and bone quality.

The Mason type I fractures involving less than 25% of the radial head and a small intra-articular step (<2mm) can be treated non-operatively with splinting and early mobilization[1]. In few published literatures, it has been reported that even large displaced fractures, which do not interfere with rotation, can be successfully managed non-operatively with early mobilization[2], [3]. The management of Mason type II injuries is less clear with evidence supporting both non-operative treatment[4] and internal fixation[5]. Most clinicians experience disappointment with the treatment of radial head fractures of Mason type III. The surgical options include fragment excision, radial head resection, repair and replacement of the head. Lopiz et al.[6] in retrospective study recommended radial head excision for treatment of comminuted radial head fractures without associated instability because of good functional outcome after radial head excision, and the high complication rate in the radial head replacement group. Miller et al.[7] in his review article mentioned that radial head resection is just as successful after a delayed period as it is in the acute setting; therefore, author recommended using either radial head replacement or ORIF in the acute setting, specifically in an unstable elbow. Radial head resection would be an option if the outcome of an acute operation was not satisfactory, but only following restoration of forearm stability. ORIF and the radial head replacement have been used in the treatment of radial head fracture of Mason type III in recent years due to frequent post-operative complications of radial head resection. The purpose of this review was to study the outcomes of the ORIF and replacement in the unstable and multi-fragmented radial head fracture.

CLASSIFICATIONS

Mason's classification[8]:

- **Type I :** fissure fractures or marginal sector fractures without displacement.
- **Type II:** marginal sector fractures with displacement.
- **Type III:** comminuted fractures involving the whole head of the radius.

Broberg and Morrey classification[9]:

Mason's original classification was modified by Broberg and Morrey to include the parameters of displacement and size

- **Type I:** fracture of the radial head or neck with <2mm displacement.
- **Type II:** fracture of the radial head or neck with displaced ≥2mm and involving >30% of the articular surface.
- **Type III:** comminuted fracture of the radial head or neck.
- **Type IV:** elbow dislocation with any fracture of the radial head [10]

Hotchkiss classification[11], [12]:

It is modified Mason's classification that aim to direct the treatment

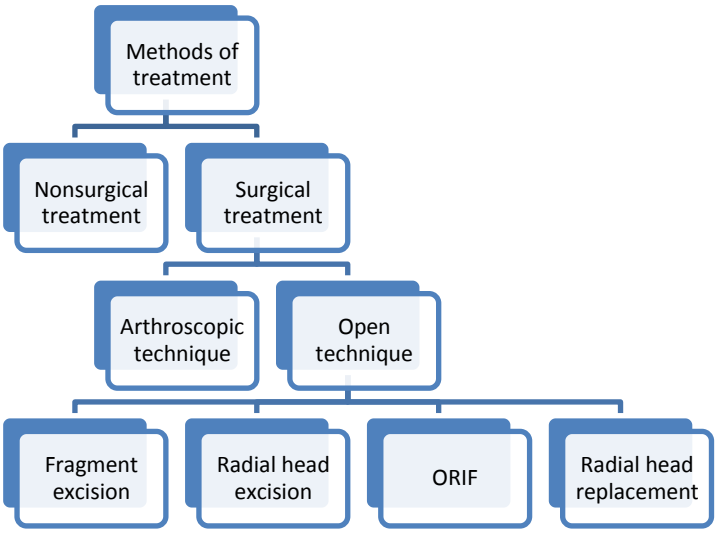
- **Type I:** Non displaced or minimally displaced fracture of the head or neck; forearm rotation limited only by acute pain and swelling (no mechanical block); intra-articular fracture displacement usually <2mm or marginal lip fracture
- **Type II:** Displaced (usually >2mm) fracture of the head or neck (angulated); motion may be mechanically blocked or incongruous; without severe comminution or fracture that involves more than a marginal lip of the radial head
- **Type III:** Severely comminuted fracture of the radial head and neck; mechanical block to motion; judged not reconstructible on the basis of radiologic or intra-operative appearance.
- **Type IV:** Radial head fracture with associated elbow dislocation

(Fractures may have associated injuries; for example- interosseous ligament injury, posterior elbow dislocation with or without coronoid fracture).

TREATMENT

Assembling the clinical presentation, physical examination and imaging into an effective treatment plan can be challenging. The characteristics of the radial head fracture influence the technique used to optimize the outcome. Fragment number, displacement, impaction, associated injuries and fractures and bone quality are considered when deciding between early motion, fragment excision, radial head excision, repair or replacement. The goal of treatment is a successful functional outcome which can be achieved by accuracy of anatomic reduction and restoration of mechanical stability.

Methods of treatment:



SURGICAL TECHNIQUE

Surgical approaches:

1. Kaplan direct lateral approach (interval between EDC and ECRB)
2. Kocher posterolateral approach (interval between ECU and anconeus)
3. Hotchkiss approach (direct through EDC)

(EDC= extensor digitorum communis ECRB= extensor carpi radialis brevis ECU= extensor carpi ulnaris)

ORIF Technique:

The patient is placed supine on the operating table with the arm on the hand table or can be brought across the chest. A tourniquet is applied and the arm is prepared and draped. The position of the upper arm is maintained in slightly abducted, elbow extended and forearm pronated.

Following Kocher posterolateral approach; incision is made beginning at the lateral condyle, along the mid axial line of radial head and ending just distal to the radial neck. The interval between the anconeus and the ECU is entered and the lateral collateral ligament (LCL) is exposed. The LCL can also be exposed by entering between the lower muscle fibers of ECU. To the exposed LCL, longitudinal incision is made in its anterior part along its fibers extending from the lateral condyle to just distal to the radial neck through the annular ligament and capsule. The intra-articular hematoma is evacuated and irrigated.

The fractured radial head fragments should not be detached from any remaining synovial or

periosteal soft tissue attachment and the fragment that is tilted and impacted into the shaft is gently elevated to anatomical level to restore the head-neck and radiocapitellar relationship, alignment and anatomical position. In some cases, the radial head is removed and assembled on the back table. This can cause loss of blood supply provided through the remaining soft tissue attachments so preservation is preferred. During reduction process, often at isthmus between neck and shaft, cancellous bone defect may be encountered. If so, autologous bone graft, allograft or bone-graft substitute can be used. Autologous bone graft is commonly used. The reduced fractured fragments are held together with small forceps or tenacular clamps or are temporarily fixed with 1.0 Kirschner wires (K-wires). If the fragments are large enough are fixed with Herbert screw. When there is concomitant fracture of the radial head and neck, reconstruction of the articular disc with the use of buried implants may be performed first and then plate fixation may be used to secure the head and neck. The radial head is fixed to shaft with T-shaped low profile mini plates (2.0mm or 2.4mm), within the safe zone. The plates can be bent to shape so as it fits perfectly to the radial neck. The screw on the radial shaft should perforate the opposite cortex while on the radial head the tip of the screws are inserted into subchondral bone but do not perforate the opposite articular cartilage.

After fixation, the alignment and mobility of the radial head are examined, both radiologically and manually manipulating the forearm. Irrigation is done and suction drain is placed and closed in layers.

Replacement technique:

As described above, patient is placed in supine position and the arm prepared and draped. Following Kocher posterolateral approach; incision is made and entering the interval between the anconeus and ECU, LCL followed by intra-articular joint space is exposed. The radial head, radial collateral ligament and the overlying extensor muscles are elevated anteriorly off the lateral condyle for the better exposer. If further exposure is needed, posterior component of the LCL can be released but careful ligament repair is required at the end of the procedure to treat the resulting instability. This exposer also facilitates the implant placement. The intra-articular hematoma is evacuated and irrigated.

The fragments of the radial head are removed and reassembled. Reassembling helps to determine the appropriate radial head implant. Using oscillating saw at right angle to the medullary canal, radial neck is removed and the surface is made smooth for seating the implant. Drill hole is made in the shaft of the radius. The medullary canal of the radial neck is reamed using hand rasps until cortical contact is encountered with a goal to achieve a non-tight fit of the trial stem. A trial head is coupled to the stem and the appropriate prosthesis is chosen. The radial head prosthesis should articulate at the same height as the radial notch of the ulna. Alignment conformation of the prosthesis is conformed and following head replacement, LCL and extensor muscle origins are reattached to the lateral epicondyle. The wound is irrigated and closed in layers.

DISCUSSION

The radial head fracture management has become one of the debates among the surgeon, regarding what should be the appropriate protocol for the selecting radial head resection, ORIF and radial head replacement. Because of today's demand for a greater degree of satisfaction, ORIF and radial head prosthesis replacement is widely used. Treating the unstable, multi-fragmented radial head fracture with ORIF or RHA is for stable fixation and restoration of the head-neck relationship.

Treating unstable, multi-fragmented radial head fracture with ORIF is challenging. There are few literatures which reported good surgical outcome in Mason type III radial head fracture and fracture dislocation[13-15].In closed comminuted radial head fracture (modified Mason type III and IV) with ORIF and RHA demonstrated similar findings despite less surgical time for performing RHA [16]. During ORIF of unstable and multi-fragmented, some fragments may be lost in the soft tissue or lack blood supply. Lost fragments can cause partial head defect and the fragments with lack of blood supply can increase the incidence of internal fixation failure. It has been reported that stable fixation and the protection of the blood supply are difficult for severe comminuted fractures [16-18]. ORIF can be attempted if there are no lost fragments; fragments do not lack blood supply; 3 or fewer fragments without impaction or deformity; fragments with sufficient size and bone quality to accept screw fixation; little or no metaphyseal bone loss [19] and if the reduction has relative stability and radial head replacement is useful if radial head is irreparable to restore elbow and forearm stability [20, 21]. Some surgeons believe that ORIF should be attempted initially, followed by prosthesis replacement if the initial outcome proves unsatisfactory [15] but, it has also been reported that multiple operations can increase the probability of poor function of elbow due contraction of nearby soft tissue scar and also increases the risk of heterotopic ossification[18, 22]. Careful and skillful attempt should be made if we decide to go with ORIF as subsequent report have found that unstable, displaced, multi-fragmented fractures of the radial head are subject to early failure, nonunion and poor forearm rotation after operative fixation[23-27].

A. Lott et al.[28] Concluded that Radial head arthroplasty is an effective option for treatment of unstable elbow injuries, with recovery of functional elbow range of motion. The complications in unstable group were heterotopic ossification, post-traumatic arthritis, periprosthetic lucency, abnormal radiocapitellar alignment and in stable group, removal of the radial head and requiring revision surgery. Chen et al[29] investigated 45 (23 ORIF group; 22 replacement group) patients with unstable, multi-fragmented fractures of the radial head. After two years follow up; Broberg and Morrey scores recorded in radial head replacement group showed significantly better clinical results with 91% good or excellent compared with 65.2% good or excellent results in ORIF group. The post-operative complication rate of the radial head replacement group (13.6%) was significantly lower than that of ORIF group (47.9%). Compared with ORIF, replacement resulted in the favorable joint function. The authors concluded that replacement is more effective than ORIF in clinical practice. Liu R. et al[18]compared radial head prosthesis replacement with

ORIF, classified as Mason type III in 72 elderly patients. 37 cases received radial prosthesis and 35 cases were treated with ORIF. All patients were followed-up for 10 to 15.6 months. Based on the elbow functional evaluation criteria score by Broberg and Morrey, 29 cases achieved excellent results, 7 were good and 1 was fair in the replacement group. In the ORIF group, excellent results were seen in 24 cases, good in 9 and fair in 2. The rates of good or excellent results were 78.4% and 68.6% for prosthesis replacement patients, respectively ($P<0.05$). The Visual Analogue Scores (VAS) for replacement and ORIF groups were 2.25 and 1.67, respectively ($P<0.05$). The authors concluded that radial head prosthesis replacement treatment is superior to ORIF treatment for the treatment of elderly patients with Mason type III radial head fractures. A meta-analysis [30] comparing ORIF and radial head arthroplasty (RHA) in patients with radial head fractures (modified Mason type III and IV) reported that RHA has better outcome than ORIF with medium-short-term follow-up period. A systematic review and meta-analysis [31] compared the complication and satisfaction rate between ORIF and RHA in the treatment of Mason type III radial head fractures. The study revealed a higher complication rate for ORIF than RHA (58.1% versus 13.9% respectively). The satisfaction rate was lower for ORIF than RHA (51.6 % versus 91.7 %).Radial head arthroplasty has proven to restore elbow stability for monopolar as well as bipolar metal implants [32]. Ruan et al.[33] concluded that bipolar radial head prosthesis replacement is better than ORIF in the treatment of Mason type III radial head fracture. Even, good long term clinical results have reported for the bipolar radial head implant [34, 35].

StéphanieDelclaux[36] in review article reported thatthe main complications are related to loosening whether they are cemented or not cemented. Pain and stiffness are other common complications often related to oversized radial head component or overstuffing of the joint with excessive lengthening of the radius. Elbow instability can be another complication in the context of more complex trauma with lateral collateral ligament complex lesion and coronoid fracture. Finally, osteoarthritis is common with follow-up. Several studies confirm that the onset of HO can trigger pain, stiffness, loss of elbow ROM, and functional impairments [37], [38].S.H. Bowman et al [39] reported that formation of HO following radial head arthroplasty predicts significantly lower postoperative range of motion and increases the risk of reoperation. Authors recommend prophylaxis against HO with NSAIDs or radiotherapy if there are no direct patient contraindications, given the negative effect of HO following radial head arthroplasty. A retrospective search[40]concluded that management of Mason type III and Mason type IV with anatomic radial head replacement leads to a good functional recovery, even in presence of severe instability, such as coronoid fractures and LUCL (lateral ulnar collateral ligament) injury. However patients should be informed of high number of adverse events (mainly HO) following treatment. Schnetzkeet al [41] study demonstrated that prosthesis over-sizing (≥2mm) could induce other radiographic abnormalities (heterotopic ossification, radiolucent lines around the prosthesis, joint incongruence, humeroulnar osteoarthritis and capitellar erosion) with then deteriorated outcome. It has been demonstrated that 2.5mm of over-lengthening or more can alter elbow joint kinematics and radiocapitellar joint pressures. High removal and revision rate is seen

with lower age (younger patients) and silastic implants [42]. Loosening of press-fit radial head prostheses is common, occurs early, often leads to severe osteolysis of the proximal radius, and commonly requires removal of the prosthesis [43]. Moghaddam A et al.[44] concluded that the current classification of fractures based on Mason and AO is neither helpful in determining proper treatment nor in judging prognosis for high grade radial head fractures. This is because the role of ligament injury of the elbow is not taken into account. Authors in their study found that in comminuted radial head fractures with elbow instability can be treated well with a modular metallic radial head prosthesis, which restores stability and integrity of the joint.

CONCLUSION

Management of unstable and multifragmented radial head fracture is based on both injury-specific factors and patients factors. Injury-specific include fracture size, displacement, rotation block and associated injuries. Patients factors include age, associated injuries, bone quality and activity level. Management choice for the age specific, especially for young patients is really challenging.Unstable and multi-fragmented radial head fractures are difficult or impossible to fix so it is not definitively possible to clarify whether fixation or replacement has better outcomes. Despite the unclear choice of treatment method, RHA can be thought ofif the radial head is irreparable and ORIF if the fracture reduction relative stability can be maintained.

REFERENCES

1. Jordan, R.W. and A.D. Jones. (2017) Radial Head Fractures. Open Orthop J, 11, 1405-1416. https://doi.org/10.2174/1874325001711011405
2. Akesson, T., et al. (2006) Primary nonoperative treatment of moderately displaced two-part fractures of the radial head. J Bone Joint Surg Am, 88, 1909-14.
3. Duckworth, A.D., et al. (2012) Socioeconomic deprivation predicts outcome following radial head and neck fractures. Injury, 43, 1102-6. https://doi.org/10.1016/j.injury.2012.02.017
4. Guzzini, M., et al. (2017) Nonsurgical treatment of Mason type II radial head fractures in athletes. A retrospective study. G Chir, 37, 200-205.
5. Demiroglu, M., et al. (2016) Results of screw fixation in Mason type II radial head fractures. Springerplus, 5, 545-551 https://doi.org/10.1186/s40064-016-2189-2
6. Lopiz, Y., et al. (2016) Comminuted fractures of the radial head: resection or prosthesis? Injury, 47, S29-s34. https://doi.org/10.1016/S0020-1383(16)30603-9
7. Miller, G., et al. (2013) Surgical management of Mason type III radial head fractures. Indian Journal of Orthopaedics, 47, 323-332. https://doi.org/10.4103/0019-5413.114907
8. Mason, M.L. (1954) Some observations on fractures of the head of the radius with a review of one hundred cases. British Journal of Surgery, 42, 123-132. https://doi.org/10.1002/bjs.18004217203

9. Broberg, M.A. and B.F. Morrey. (1987) Results of treatment of fracture-dislocations of the elbow. ClinOrthopRelat Res, 216, 109-19. https://doi.org/10.1097/00003086-198703000-00017

10. Johnston, G.W. (1962) A Follow-up of One Hundred Cases of Fracture of the Head of the Radius with a Review of the Literature. The Ulster Medical Journal, 31, 51-56.

11. Hotchkiss, R.N. (1997) Displaced Fractures of the Radial Head: Internal Fixation or Excision? J Am AcadOrthopSurg, 5, 1-10. https://doi.org/10.5435/00124635-199701000-00001

12. Kumar, V. and W.A. Wallace. (2012) Radial head fractures – update on classification and management. Orthopaedics and Trauma. 26, 124-131. https://doi.org/10.1016/j.mporth.2012.04.002

13. Koslowsky, T.C., et al. (2007) Reconstruction of Mason type-III and type-IV radial head fractures with a new fixation device: 23 patients followed 1–4 years. Actaorthopaedica, 78, 151-156. https://doi.org/10.1080/17453670610013565

14. Ikeda, M., et al. (2006) Comminuted Fractures of the Radial Head: Comparison of Resection and Internal FixationSurgical Technique. JBJS, 88, 11-23. https://doi.org/10.2106/00004623-200603001-00002

15. Crönlein, M., et al. (2017) Using an anatomically preshaped low-profile locking plate system leads to reliable results in comminuted radial head fractures. Archives of orthopaedic and trauma surgery, 137, 789-795. https://doi.org/10.1007/s00402-017-2693-z

16. Al-Burdeni, S., et al. (2015) Open reduction and internal fixation versus radial head arthroplasty in the treatment of adult closed comminuted radial head fractures (modified Mason type III and IV). International orthopaedics, 39, 1659-1664. https://doi.org/10.1007/s00264-015-2755-1

17. Watters, T.S., et al. (2014) Fixation versus replacement of radial head in terrible triad: is there a difference in elbow stability and prognosis? Clinical Orthopaedics and Related Research®, 472, 2128-2135. https://doi.org/10.1007/s11999-013-3331-x

18. Liu, R., et al. (2015) Comparison of primary radial head replacement and ORIF (open reduction and internal fixation) in Mason type III fractures: a retrospective evaluation in 72 elderly patients. Medical science monitor: international medical journal of experimental and clinical research, 21, 90-93 https://doi.org/10.12659/MSM.893048

19. Ring, D. (2011) Radial head fracture: open reduction–internal fixation or prosthetic replacement. Journal of shoulder and elbow surgery, 20, S107-S112. https://doi.org/10.1016/j.jse.2010.11.011

20. Yu, W., et al. (2016) acute unstable complex radial head and neck fractures fixed with a mini T-shaped plate in a 20-year-old man: a case report. Therapeutics and clinical risk management, 12, 825-830 https://doi.org/10.2147/TCRM.S107640

21. Li, L., A. Patel, and A. Rashid. (2016) Functional Outcomes of Fixation Versus Replacement for Comminuted Radial Head Fractures in Adults: A Systematic Review. International Journal of Orthopaedics, 3, 557-563. https://doi.org/10.17554/j.issn.2311-5106.2016.03.164

22. Van Glabbeek, F., et al. (2004) Detrimental effects of overstuffing or understuffing with a radial head replacement in the medial collateral-ligament deficient elbow. JBJS, 86, 2629-2635. https://doi.org/10.2106/00004623-200412000-00007

23. Heim, U. (1992) Surgical treatment of radial head fracture. Zeitschrift fur Unfallchirurgie und Versicherungsmedizin: offizielles Organ der SchweizerischenGesellschaft fur Unfallmedizin und Berufskrankheiten= Revue de traumatologie et d'assicurologie: organeofficiel de la Societesuisse de. 85, 3-11.

24. Heim, U. (1999) Combined Fractures Of The Upper End Of The Ulna And The Radius In Adults: A Series Of 120 Cases. The Journal of Bone and Joint Surgery-british Volume, 81, 363.

25. King, G.J., D.C. Evans, and J.F. Kellam. (1991) Open reduction and internal fixation of radial head fractures. Journal of orthopaedic trauma,5, 21-28. https://doi.org/10.1097/00005131-199103000-00004

26. Ring, D., J. Quintero, and J.B. Jupiter. (2002) Open reduction and internal fixation of fractures of the radial head. JBJS, 84, 1811-1815. https://doi.org/10.2106/00004623-200210000-00011

27. Ikeda, M., et al. (2005) Comminuted fractures of the radial head: comparison of resection and internal fixation. JBJS, 87, 76-84. https://doi.org/10.2106/JBJS.C.01323

28. Lott, A., et al. (2018) Results after radial head arthroplasty in unstable fractures. Journal of shoulder and elbow surgery, 27, 270-275. https://doi.org/10.1016/j.jse.2017.10.011

29. Chen, X., et al. (2011) Comparison between radial head replacement and open reduction and internal fixation in clinical treatment of unstable, multi-fragmented radial head fractures. International orthopaedics, 35, 1071-1076. https://doi.org/10.1007/s00264-010-1107-4

30. Sun, H., J. Duan, and F. Li. (2016) Comparison between radial head arthroplasty and open reduction and internal fixation in patients with radial head fractures (modified Mason type III and IV): a meta-analysis. European Journal of Orthopaedic Surgery & Traumatology, 26, 283-291. https://doi.org/10.1007/s00590-016-1739-1

31. Li, N. and S. Chen. (2014) Open reduction and internal-fixation versus radial head replacement in treatment of Mason type III radial head fractures. European Journal of Orthopaedic Surgery & Traumatology, 24, 851-855. https://doi.org/10.1007/s00590-013-1367-y

32. Hartzler, R.U., et al. (2014) Radial head reconstruction in elbow fracture-dislocation: monopolar or bipolar prosthesis? Clinical Orthopaedics and Related Research®, 472, 2144-2150. https://doi.org/10.1007/s11999-014-3672-0

33. Ruan, H.-J., et al. (2009) A comparative study of internal fixation and prosthesis replacement for radial head fractures of Mason type III. International orthopaedics, 33, 249-253. https://doi.org/10.1007/s00264-007-0453-3

34. Van Hoecke, E., et al. (2016) Long term results after bipolar radial head arthroplasty. ActaOrthopædicaBelgica, 82, 382-388.

35. Sershon, R.A., et al. (2018) Radial head replacement with a bipolar system: an average 10-year follow-up. Journal of Shoulder and Elbow Surgery. 27, e38-e44. https://doi.org/10.1016/j.jse.2017.09.015

36. Delclaux, S., et al. (2015) Complications of radial head prostheses. International orthopaedics, 39, 907-913. https://doi.org/10.1007/s00264-015-2689-7

37. Hong, C., et al. (2015) Clinically relevant heterotopic ossification after elbow fracture surgery: a risk factors study. Orthopaedics& Traumatology: Surgery & Research, 101, 209-213. https://doi.org/10.1016/j.otsr.2014.10.021

38. Ellerin, B.E., et al. (1999) CURRENT THERAPY IN THE MANAGEMENT OF HETEROTOPIC OSSIFICATION OF THE ELBOW: A Review with Case Studies1. American journal of physical medicine & rehabilitation, 78, 259-271. https://doi.org/10.1097/00002060-199905000-00016

39. Bowman, S.H., et al. (2016) The clinical implications of heterotopic ossification in patients treated with radial head replacement for trauma: A case series and review of the literature. Journal of Orthopaedics, 13, 272-277. https://doi.org/10.1016/j.jor.2016.06.011

40. Tarallo, L., et al. (2017) Mason type III radial head fractures treated by anatomic radial head arthroplasty: Is this a safe treatment option? Orthopaedics& Traumatology: Surgery & Research, 103, 183-189. https://doi.org/10.1016/j.otsr.2016.10.017

41. Schnetzke, M., et al. (2014) Radial head prosthesis in complex elbows dislocations: effect of oversizing and comparison with ORIF. International orthopaedics, 38, 2295-2301. https://doi.org/10.1007/s00264-014-2478-8

42. Duckworth, A.D. (2014) et al., Radial head replacement for acute complex fractures: what are the rate and risks factors for revision or removal? Clinical Orthopaedics and Related Research®, 472, 2136-2143. https://doi.org/10.1007/s11999-014-3516-y

43. Flinkkilä, T., et al. (2012) Short-to mid-term results of metallic press-fit radial head arthroplasty in unstable injuries of the elbow. J Bone Joint Surg Br, 94, 805-810. https://doi.org/10.1302/0301-620X.94B6.28176

44. Moghaddam, A., et al. (2016) Outcome of radial head arthroplasty in comminuted radial head fractures: short and midterm results. Trauma monthly, 21 https://doi.org/10.5812/traumamon.20201